🚗⚡ EV Charging Demand Analysis & Forecasting

📌 Project Overview

The rapid growth of Electric Vehicles (EVs) has created an urgent need for scalable charging infrastructure. This project analyzes charging behavior at the **network, station, and session level** and applies **time-series forecasting** to predict future demand. The insights enable **energy providers, urban planners, and policymakers** to make data-driven infrastructure decisions.

🎯 Business Objectives

- Identify **charging demand trends** and peak load periods.
- Measure **station-level utilization** and detect demand hotspots.
- Analyze **user and vehicle charging patterns** across sessions.
- Forecast **future energy demand** using ARIMA models.
- Provide **executive-ready KPIs** to support strategic planning.

🔄 Project Architecture / Workflow

1. **Data Collection & Integration** → Imported EV sessions, station, and network datasets.
2. **Data Preprocessing** → Cleaned datetime, standardized units, handled missing values.
3. **Exploratory Data Analysis (EDA)** → Identified trends, peak hours, and usage patterns.
4. **Feature Engineering** → Derived metrics (charging duration, rate, weather effects).
5. **Forecasting** → Applied ARIMA models to predict future demand.
6. **Visualization & Dashboarding** → Built Power BI dashboards for KPIs and drilldowns.
7. **Insights & Business Impact** → Delivered actionable recommendations for infrastructure planning.

📊 Dataset Summary

- **Sessions (572 × 21)** → User, vehicle, charging, and weather details.
- **Network Hourly (8,088 × 2)** → Hourly aggregated energy demand.
- **Station Hourly (29,122 × 3)** → Hourly demand by individual stations.
- **Energy Consistency** → All datasets report **24,920.95 kWh total consumption**.

📈 Key Findings

- **Total Sessions**: 572
- **Total Energy Consumed**: **24.92 MWh**
- **Peak Hour**: 8:00 AM
- **Peak Demand**: **1,231.12 kWh**

- **Best Weather Condition**: Cloudy (highest charging activity)

🔮 Forecasting Results

- **Model**: ARIMA (Auto-Regressive Integrated Moving Average)
- **Performance**:
    - MAE: **3.71**
    - RMSE: **13.95**
- **Forecast Horizon**: 1 week & 1 month ahead

The forecast captures **hourly demand variations**, enabling operators to anticipate load fluctuations and optimize grid utilization.

📊 Dashboard Insights (Power BI)

The interactive Power BI dashboard provides:

- **Network View** → Demand trends across the entire network.
- **Station View** → Utilization differences and demand clusters.
- **Session View** → Charging duration, rates, and weather influence.
- **KPIs** → Executive-ready metrics for quick decision-making.

⚙️ Tools & Technologies

- **Python**: Pandas, Statsmodels (ARIMA), Prophet, Matplotlib
- **Power BI**: Interactive dashboards & KPI reports
- **Excel/CSV**: Data preprocessing and validation

🚀 Deliverables

- ✅ Cleaned Datasets (.csv)
- ✅ Python Forecasting Notebook (.ipynb)
- ✅ Power BI Dashboard (.pbix)
- ✅ Executive Report (PDF/README)

📣 This project delivers **data-driven insights into EV charging demand**, helping accelerate the shift toward a **sustainable EV ecosystem**.